LiDAR Business Analysis

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Instructor:	Dr. William (Ike) Eisenhauer
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Authors:	Liyan Xiao Mufeed Yacoub Rassaniya Lerdphayakkarat Tyler Groth Tanzila Akhter Wendy Lally

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Executive Summary

LiDAR (Light Detection and Ranging) is a remote sensing technology that uses light in the form of a laser pulses to create 3D images. LiDAR technology's use on UAS (Unmanned Aerial System) is a relatively new concept in the rapidly advancing remote sensing & 3D imaging industry. As such, profitability data is either not released by similar business organizations, or there is simply not enough historical data to accurately predict revenue streams with either business model. To assess the feasibility of business models, market research and literature review were performed by our research team. Economic analysis methods were used to determine the most advantageous business plan strategy for the LiDAR business opportunities. Since the success of either business model will rely heavily on the company's sales ability. Since the focus of this report is on economic analysis to make the best business decision, we have made our valuation calculations based conservative sales forecasts.

The startup business plan identifies and critiques two business models identified by the founder entrepreneurs:

1. A service oriented model in which data is collected, processed, and delivered by an operations team to the customer.
2. A product oriented model in which LiDAR UAS is constructed, tested, and sold as a unit that includes training as an entire product for the customer's own use.

Based on these two models, three decision options were evaluated and compared with each other:

1. Invest in the Service only model
2. Invest in the Product only model
3. Do not invest, utilize the stock market for investment gains

A 5-year cash flow analysis was conducted to give the founders a recommended strategy to optimize their investment. Through conducting a benefit cost analysis and calculating the internal rate of return of each opportunity, it was determined that both business models may be profitable and worthy investments. The expected IRR of service model and product model are 56% and 136% respectively. They are both much higher than the stock market option, which has an estimated MARR of 8% on average.

Much of the risk in this analysis was the uncertainty in the sales revenue projections. The team endeavored to determine the sensitivity of the data by performing sensitivity analysis on these sales projections. Expected values were calculated taking into consideration of the most likely, optimistic and pessimistic cases. The sensitivity analysis result shows both business models are profitable under all conditions.

The economic analysis has shown that while both business models are likely to be profitable, the Product Business Model has the potential for a higher return on investment. Therefore the research team recommends that the investors proceed with the Product Business Model outlined in the report.

Introduction

Background

LiDAR (Light Detection and Ranging), is a remote sensing technology that uses light in the form of a laser pulses to measure distances to an object. These laser pulses can be transmitted and received at rates of 300,000 to over one million pulses per second (depending on the type of sensor). This high sample rate of range data allows one to construct high resolution 3D models of terrain or objects. With the use of an aircraft, the LiDAR sensor can easily cover large areas with multiple look angles resulting in large dense 3D point clouds. The raw LiDAR data is post processed with special software that constructs the point cloud and filters noise. The software also imbeds GPS location of the aircraft along with the aircraft's IMU (inertial measurement unit) for the angle of the sensor due to aircraft pitch, roll, and yaw. These location and position data sets make it possible to accurately register the LiDAR point cloud to its actual location on other GIS programs such as Google Earth and Global Mapper. LiDAR data sets provide far more accuracy with respect to elevation changes, foliage density, small object measurement the aerial photo camera and satellite optical systems.

In the last few years, consumer Unmanned Aerial Systems for commercial applications has increased exponentially. This is due to reduction in barriers to entry. Government support is primarily from the FAA which has formalized a step by step process to become a licensed UAS pilot. Advancement in autonomous navigation software, hardware, & propulsion systems have also reduced the barrier to entry. The expanding UAS market has incentivized remote sensing and imagery manufacturers to build products that are smaller and lightweight for these UAS to carry. Only in the last two years have LiDAR capabilities been available for consumer and commercial drone use.

The founders have experience in both manned and unmanned aerial intelligence & surveillance systems when they served in the U.S. Air Force and as civilians. These systems were used for Department of Defense operations globally. With the vast reduction in acquisition costs of consumer drones and sensor technology, the founders have been researching the need of LiDAR data sets for construction and utilities firms. These firms would use LiDAR data sets for many uses including project completion monitoring & auditing, structural inspection, electrical code compliance, excavation volumes, foliage measurement, and repose angles.

Problem Statement

When creating a business, it is imperative to be aware of the likely cash flow, costs and benefits of the planned business model.

This LiDAR technology startup has two possible business models which the founders are exploring:

1. Service Model - Fly the drone, collect the data, and sell the data to customers as a SERVICE

The Service model will provide clients with a final product consisting of mapping data. This service will utilize an in-house built LiDAR drone system to survey desired landscape by an operator, who will also process the hard data and deliver a detailed visual 3D like map to the client.

2. Product Model - Integrate the hardware & software, and create a training plan in order to sell the complete mapping/scanning system as a PRODUCT

The product model will provide the consumer an all-in-one system to support a variety of surveying functions. The product will mainly consist of the drone, and the necessary LiDAR hardware to collect the data attached to it. Training will also be provided to the customer to illustrate how to collect and process the data.

The founders/investors would like the research team to identify which opportunity would be most lucrative to pursue. Profitability, payback period, and cost/benefit ratio are among the information the founders/investors need in order to make the business decision.

Company Overview

Operations

This company is a two person startup, with a split of 50% equity to each founder. The startup budget is $50,000. The company has chosen a sales person already who will be awarded 10% of each contract he negotiates with a client.

This salesperson will have an equal incentive for each type of customer which would be approached. For example, large construction firms would be more inclined to purchase their own LiDAR UAS and thus the product model would be ideal. Firms with smaller budgets or groups who only need a one-time scan would likely prefer the lower cost service model. In order to reduce variables in the economic analysis, in either model it's assume that the salesperson would target both types of customers without regard to personal benefits. i.e. 1 unit of sale for the product is a greater payout to the salesperson than 1 unit of sale for the SERVICE model.

The first 12 months the company will operate out of the first founder's garage. This will be the work space for integrating the UAS, storing the UAS, processing data, and any other technical work that might need to be done. The garage is suitable for either business model. The garage is a low cost alternative to an office given the working capital constraints. The company expects

it will use all of the $50,000 to get either business model operational, and so it plans to not take on any debt in order to hire employees during this time as the founders plan to work on the weekends or take turns servicing clients during the week. The salesman will work part time in the beginning, as will the founders. They will not quit their full time jobs. Once a brand, track record, and customer base has been established, the company will hire employees for specific roles based on each business model. The plan for the first year emphasizes our conservative startup approach.

Standard small business liability insurance would be purchased in either business model. Travel costs for the target market of a 100 mile radius will also be reimbursed to sales rep and field operations or training personnel.

Employees

Starting the second year, the company would hire a different employee base for each business model. The costs of these employees based on competitive hourly rates for people in the greater Portland area with the base skills necessary to perform the work. Base skills meaning, they must be enthusiastic to perform the work and have work experience that is at least similar to this industry (Geographical Information Systems, remote sensing, drone operation, systems engineering). Most people do not have a background in LiDAR, photogrammetry, or point cloud data processing. Therefore, it is expected that the company founders will have to extensively train the employees on the processes and procedures that have been developed during the first year.

In order to establish a successful product model there are two major factors, or rather personnel, who are essential to the company. The first employee is the salesperson. The salesperson will essentially be driving the show. The second employee is the assembly engineer. This engineer will need to be quite skilled technically and socially, as the job entails both assembling the drone and the LiDAR components together and training the customers on how to use the final product. More details on the employee structure are in the Company Overview section, below.

The service model team would consist of one sales representative, one qualified drone operator who can also process the data for the customer. There would also need to be a schedule manager to take calls and schedule service requests. Similar to the product model, the good salesperson is critical to the success of this service model. This model is heavily reliant on small to medium scale projects, as opposed to large ones; i.e. forest surveying. So, the knowledge of this market niche is necessary for the salesperson to have.

Methodology

For analyzing the LiDAR business, the following steps were implemented: literature review, cost-benefit analysis, sensitivity analysis, and alternative analysis. From the literature review the team attempted to understand how much Lidar market is growing. Some of the questions tackled are: which are possible target markets for LiDAR? How does construction use LiDAR? How do Utility firms use LiDAR? After getting an overall idea of the market, the next step was to conduct cost-benefit analysis. In this analysis, the team determined how much money should be invested, and what the rate of return could be for each of the proposed business models. The third step was to focus on sales projections by doing a sensitivity analysis as the sales projections were determined by the team to have the most risk. The last step was to compare the financial analysis data of all options and determine which model would be the most financially lucrative for the founders.

Literature Review

Financial concepts

Generally, each project has alternatives and different benefits and values. Hence, it is necessary to use financial criteria and engineering economics to compare and select among alternatives and to determine the most valuable alternative. In the engineering economics concept, cash, interest rate, and time are three main parameters to consider in term of interest periods. These comparisons involve analysis of present worth (PW), future worth (FW), net present value (NPV), internal rate of return (IRR), benefit/cost ratio, and payback period [1].

NPV is used to calculate the present value of future cash flows in excess of the present value of the investment spending based on the minimum attractive rate of return (MARR). Usually, MARR is utilized for discounting and the investment alternative that has greater NPV will be selected. IRR analysis is used to find the interest rate that makes cash flows and cash outflows equal. Payback period analysis calculates the time necessary for an investment alternative to pay for itself. Benefit/Cost ratio analysis evaluates projects based on the ratio of benefits to costs. In this project, the research team applied all of these functions to consider costs and benefits that occur at different times and the time value of the money.

We did not apply depreciation in this study, because we did not consider the tax aspect of the business. Equipment required for both business models are identical. Tax rate should be the same for both business models, too. Therefore depreciation won't affect the results of this study. Salvage value of equipment was not considered either. Since the study was conducted for 5 years only and business owner has no intention to retire or replace these equipment within 5 years.

Market Analysis

Low cost aerial LiDAR mapping is a relatively new concept, and is being explored within the industry as a solution to many common surveying problems. The purpose of this marketing literature review is to give the team a rough baseline for what the most popular usages are for the technology as well as where the industry seems to be moving. Originally the team's goals for the literature review were to collect financial data on the companies as well as price points. Due to the early stage of innovation with these technologies, no data of that type was available in mid-2017.

In the literature review of the LiDAR technology, the following industries have been identified as possible clients for either business model: Mining, Oil and Gas, Agriculture and Forestry, Construction and Development Planning, Infrastructure and Utilities and Emergency and Disaster [2]. This team's research focused on two areas identified by the founders as "areas of interest": Construction and Utilities.

Utility Industry

The utility industry is one of the fastest growing markets for LiDAR. Identifying optimum facility and infrastructure locations is the main concern for utility companies. For that purpose, they are using airborne LiDAR in conjunction with high-resolution satellite imagery. By using highly accurate images, utility companies have a precious information resource for planning and maintaining. LiDAR image could advance in monitoring various utility corridors; it also could provide a unique combination of accuracy and efficiency. [9]

Some examples of LiDAR company offerings for utilities are:

- Sanborn company offers a full service for electric corridor mapping. [10]
- LiDAR Drone services offers on electrical and HVAC issue. [11]
- Compass data working on several sectors like telecom cell tower mapping to utility mapping. [12]

Utility companies are using LiDAR for cost reduction. Improperly rated lines are costly. Many companies are working together to clear the vegetation on power lines by using Lidar. By using LiDAR the user can measure the clearance between lines and vegetation [13]. There are many utility companies like PG&E, some oil and gas companies are using drones to achieve better results. In fact, PG&E has already tested it [14]. They thought that, using Unmanned Aerial Systems or drones is safe & reliable. They want to work with other companies to ensure the safe operations of drones. Remote sensing drones equipped with Lidar can produce accurate information of environment such as height, elevation, site analysis [15].

Though most of the companies are still using paper maps or hand-written notes, many of them are already using advanced technology of LiDAR and/or Drone. It's not far off, that one day each company, big or small, would use LiDAR to stay competitive in the market.

Construction Industry

Typically in construction, areas are mapped prior to excavation and building by traditional

surveying techniques using lasers. Precise excavation or fill plans and topology can be created. This traditional surveying can be replaced by LiDAR capture and modeling. Another construction use is to assess existing structures, or structures under development. An example of this is fly-overs to show progress compared to an existing construction plan.

Startup LiDAR companies are entering the construction industry with many different business models. Some are selling LiDAR drone products as well as offering one-time services of LiDAR mapping; others do one or the other [5]. Some examples of company offerings are:

- Kespry offers a platform complete system, including an iPad based routing app, a drone, tools for processing and reporting functionality. [6]
- Phoenix LiDAR Systems offers to build its customers “compact, multi-vehicle compatible, survey-grade laser mapping & photogrammetry solutions”. They have multiple products offered covering both ground based (traditional surveying) as well as UAV mounted LiDAR units. [7]
- LiDAR Drone Services offers 3D mapping services combined with thermography to detect heat discrepancies. The additional thermography allows them to identify insulation and moisture issues, electrical issues, and cement delamination in an overlay to the LiDAR mapping. [5]

General LiDAR Market

U.S. represents more than 80% share of the overall aerial LiDAR system market in North America. According to the published report by Allied Market Research, the U.S. airborne LiDAR market is expected to garner $135 million by 2022, growing at a CAGR (Compound annual growth rate) of 12.1% from 2016 to 2022. Due to expansion of airborne LiDAR applications in various industries, reduction in price of drones and reduction the cost of airborne LiDAR sensors, the demand for the airborne LiDAR has increased. Moreover, the high demand for accurate and high-resolution 3D images of the tracked object are most widely used in aerospace and civil engineering, forestry and agriculture, transportation and logistics. Hence, rising demand for 3D imaging projected to supplement the market growth [3].

Another estimating source, Marketsandmarkets.com expects the value of the LiDAR industry to reach $5.2 billion by 2022, growing at a CAGR of 25.8%. The market forecast is based on component, product, service, application, and geography. In this project, we focus on the product and the service alternatives. The feasibility of this LiDAR business faces strong challenges due to growing competition and higher prices than other aerial imagery services. Therefore, we came up with three different possibility of market growth project, which are most likely case of 15% annual growth, optimistic case of 25% annual growth, and pessimistic case of 10% annual growth [4].

Financial Analysis

Financial analysis was conducted on the service business model and product business model to

give the founders a recommended strategy to optimize their investment.

In order to compare the projected financial performance, a five year cash flow was constructed for each business model. The costs and benefits of each model were estimated based on the current market situation and projected sales in the coming 5 years. From the 5 year cash flow, the NPV, IRR and B/C ratio were calculated for each business model. The accumulative cash flow of each business model was also graphed to show the payback period of each option.

Since sales projection is the factor that causes most uncertainty in our calculation, we additionally conducted sensitivity analysis using three different possibility cases: most likely case (50% chance), optimistic case (25% chance) and pessimistic case (25% chance). Expected values were calculated as the sum of products of projected sales and possibility cases. The expected value is a probability-weighted average of all possible values, and considered closest to true value.

The expected values of both models were then compared, side by side with the "Do Nothing" option. This comparison provides a good visual for the founders in their business strategy decision making.

Depreciation and Salvage value of equipment by end of life were not included in the analysis.

Service Business Model Option

Cash Flow Analysis

The cost of service model consists of two parts: fixed costs and variable costs. The table blow summarizes the various costs of this business model.

Item	Amount	Notes
Fixed Costs		
LiDAR/Drone System	$42,200/unit	Purchase 1 unit in Y0 for business use
Business Insurance	$3,000/year	Assuming no major incident and insurance cost stays the same for 5 years
Software licensing Fee	$1,700/year starting Y2	Y1 software licensing fee is included in the purchasing price of the LiDAR/Drone System
Work Truck	$500/month lease $20,000 purchase	Lease in Y1, since the initial investment is insufficient to purchase. A work truck will be purchased as soon as the company could make sufficient cash profit to pay for it in full. No finance is considered on truck purchasing. Buying truck after leasing is due to customization needs and desire for mobile marketing vehicle

Office Space Rental	$1,200 in Y1 $22,500/year starting Y2	The two founders will work off their garage during Y1. A 900 square feet office space will be rented starting Y2 at $25 per square feet per year..
Schedule Manager	$25,000/year with 3% annual	A full time schedule manager will be hired starting Y2 to handle daily office work and scheduling, located at the rented office space.
Variable Costs		
Drone Operator/ Data Processor	$30/hour	The two founders are able to work 32 hours per month per person with no pay during Y1. A specialist will be hired when projected sales exceeds the two founders' capacity. Based on the speed and battery life of the UAS, we expect the service operator to be able to scan 10 acres in one day. Some days might run past the eight hour standard due to traveling to job sites. This is why we pay the service operator an hourly wage.
Marketing	$2,000+10% of revenue in Y1 10% of revenue starting Y2	The initial $2000 will be used to cover the setup of company website, social network, company logo design, etc.
Sales	10% of total revenue per year	The sales representative is 100% commission-based. No annual salary is offered. He is already lined up and is keeping his current job
Travel Cost	$1/mile	Travel cost to cover the gas cost when traveling to work site, which is normally in remote area. Round Trip.

The benefit of service business model comes from selling LiDAR photo taking and data processing services. The acreage based service charge and the first year sales projection are as shown in the table below. The service charges are the current average market price of similar services.

Service Type	Service Charge	Y1 sales projection
Photo Only	$300/acre	20 acres
LiDAR only	$400/acre	60 acres
Photo/LiDAR Combination	$600/acre	80 acres

Sales projections in Y2-5 used for this analysis were based on the literature review conducted. In the most likely case, the LiDAR on UAS service is expected to grow 15% each year.

The following assumptions were considered when calculating annual benefit of this service model:

- Average job size is 10 acres/job
- Scanning and processing time is 20 hours/job
- Average travel distance: 100 miles/job round trip
- Maximum capacity of Drone Operator/Data Processor is 10 jobs/month/person

Appendix A shows the detailed 5 year cash flow, as well as the calculated NPV, IRR and B/C ratio from this cash flow. The NPV of this cash flow is **$53,120**, which is larger than the initial investment. The IRR of this cash flow is **53%**. The average B/C ratio of the 5 years is **1.5**. All these numbers show that the service model is profitable.

Appendix B shows the accumulative cash flow of 5 years. The initial investment could be paid back by end of Y1. The profit made in year 1 is sufficient for the company to purchase a work truck in the beginning of Y2. The truck purchase would cause the cash flow by end of Y2 to be negative, but this second investment would be paid off in Y3. The short payback period is an advantage to a small business like this. The business owners will be able to invest the profit back into the business quickly to help grow the company. The reason the company would not continue to lease the truck and would like to purchases is so the truck could be customized for business needs such as painting for advertising and outfitted with tools, battery chargers, etc…

This cash flow analysis shows that this service business model is profitable and has a good potential for growth.

Sensitivity Analysis

Sensitivity analysis was conducted using three sales projection cases:

- Most likely case (50% chance) : 15% annual growth in sales
- Optimistic case (25% chance) : 25% annual growth in sales
- Pessimistic case (25% chance): 10% annual growth in sales

5-year cash flow was constructed for each probability cases. Expected values were calculated as the sum of products of projected sales and possibility cases. See Appendix C for details of these cash flows. Table below summarizes the calculated NPV, IRR, average B/C ratio of all cases.

Probability Case	NPV	IRR	Average B/C ratio
Most Likely (50%)	$53,120	53%	1.51
Optimistic (25%)	$109,363	75%	1.64
Pessimistic (25%)	$28,535	38%	1.45
Expected Value	$61,035	56%	1.53

This sensitivity analysis shows that the service model is profitable. Even in the pessimistic case, the benefit to cost ratio is still higher than 1.

Product Business Model Option

Cash Flow Analysis

The cost of production model consists of two parts: fixed costs and variable costs. The table blow summarizes the various costs of this business model.

Item	Amount	Notes
Fixed Costs		
LiDAR/Drone System	$42,200/unit	Purchase 1 unit in Y0 for business use.
Business Insurance	$3,000/year	Assuming no major incident and insurance cost stays the same for 5 years
Work Truck	$500/month lease $20,000 purchase	Lease in Y1, since the initial investment is insufficient to purchase. A work truck will be purchased as soon as the company could make sufficient cash profit to pay for it in full. No finance is considered on truck purchasing.
Office Space Rental	$1,200 in Y1 $22,500/year starting Y2	The two founders will work off their garage during Y1. A 900 square feet office space will be rented starting Y2 at $25 per square feet per year..
Assembly Engineer	$80,000/year with 3% annual	A full time assembly engineer will be hired starting Y2 to handle part purchase, assembly, testing and training customers.
Variable Costs		
LiDAR/Drone System	$42,200/unit	Part cost per unit
Marketing	$2,000+10% of revenue in Y1 10% of revenue starting Y2	The initial $2000 will be used to cover the setup of company website, social network, company logo design, etc.
Sales	10% of total revenue per year	The sales representative is 100% commission-based. No annual salary is offered. He is already lined up and is keeping his current job

The benefit of product business model comes from selling assembled LiDAR/Drone system and training and licensing service. The price of a LiDAR/Drone system and the first year sales projection are as shown in the table below. The LiDAR/Drone system price and training fees are the current average market price of similar products and services.

Item	Service Charge	Y1 sales projection
LiDAR/Drone system	$75,000/unit	4
Training and Licensing	$4000/unit	4

Sales projections in Y2-5 we used for this analysis were based on the market outlook induced from the literature review conducted. In the most likely case, the the company is able to increase sales by 2 units per year in the coming years.

The following assumptions were considered when calculating annual benefit of this service model:

- Maximum capacity of one assembly engineer is one LiDAR/Drone system per month
- Part costs of the LiDAR/Drone system will stay the same, if not going down, in the coming 5 years

Appendix D shows the detailed 5 year cash flow, as well as the calculated NPV, IRR and B/C ratio from this cash flow. The NPV of this cash flow is **$264,878**, which is much larger than the initial investment. The IRR of this cash flow is **140%**. The average B/C ratio of the 5 years is **1.1**. All these numbers show that the service model is profitable.

Appendix E shows the accumulative cash flow of 5 years. The initial investment be could be paid back within the first year. The profit made in year 1 is sufficient for the company to purchase a work truck in the beginning of Y2. Short payback period provide advantage to small business like this. The business owners will be able to invest the profit back to the business quickly to help grow the company. The reason the company would not continue to lease the truck and would like to purchases is so the truck could be customized for business needs such as painting for advertising and outfitted with tools, battery chargers, etc…

This cash flow analysis shows that the product business model is profitable with a good potential of growth.

Sensitivity Analysis

Sensitivity analysis was conducted using three sales projection cases:

- Most likely case (50% chance) : 2 units annual growth in sales
- Optimistic case (25% chance) : 3 units annual growth in sales
- Pessimistic case (25% chance): 1 annual growth in sales

5-year cash flow was constructed for each probability cases. Expected values were calculated as the sum of products of projected sales and possibility cases. See Appendix F for details of these cash flows. Table below summarizes the calculated NPV, IRR, average B/C ratio of all cases.

Probability Case	NPV	IRR	Average B/C ratio
Most Likely (50%)	$264,878	140%	1.10
Optimistic (25%)	$303,718	160%	1.05
Pessimistic (25%)	$104,159	95%	1.09
Expected Value	234,409	136%	1.09

This sensitivity analysis shows that the product model is profitable. Even in the pessimistic case, the benefit to cost ratio is still higher than 1.

Decision Options Comparison

Generally speaking, the higher a project's internal rate of return, the more desirable it is to undertake the project. Assuming the costs of investment are equal among the various projects, the project with the highest IRR would probably be considered the best and undertaken first.

We compared the IRR of the expected value of the service business model, product business model and “Do Nothing” option. When “Doing nothing”, the founder will invest their money in stock market. The average stock market MARR is roughly 8%.

Options	IRR
Service Business Model Option	56%
Product Business Model Option	136%
Do Nothing Option	8%

The comparison result shows that the **Product Business Model** option is the most profitable one.

Conclusions

Recommendations

Based on the analysis, both models provide far greater return than the MARR. Since the Product model provides the greatest IRR, sales efforts should be weighted towards those firms who would be most likely to purchase the LiDAR drone for their own use.

Either business model requires a demonstrative approach. This technology will not sell itself unless a customer is well versed in GIS and remote sensing. The salesperson will be required to explain to the customer why they need this product or service. The company feels it would be very difficult to acquire a sales contract *before* inventory (LiDAR UAS) has been purchased. Therefore, a LiDAR UAS would have to be on hand in order to prove the concept.

We'd also like to point out that the founders could continue to work in years 2 and beyond and delay the hiring of employees. This would certainly increase profitability in either business model. However, the founders have both decided to consider the value of their time in other ventures or hobbies. A "MARR of their time" if you will. Hiring employees will free them up to pursue hobbies or other business ventures.

The company made conservative sales projections in both models based on the expansion of the LiDAR industry. The company founders want to be as risk averse as possible, by not taking on debt, and not quitting their current jobs. It is quite clear that the greatest dependency for this business to work is the ability to sell. Since the product model provides by far the greatest return, the company can still profit even if sales fall short of projections. The founders have decided to opt for the product business model.

Limitations and Future Research Need

Due to time constraint and resource limitations, there are several major limitations of this study. First of all the sales projections are based on limited data which could be found on the historical financial success of competitors. While this has been mitigated somewhat by the sensitivity analysis, its accuracy is of high risk as it will directly affect the results of this report. If more accurate sale projection could be made, a study of a service and product combined model could be conducted to explore the option of implementing both the Product and the service model, and how that dynamic may work hand in hand.

Secondly, we estimate that the LiDAR UAS(s) will last the 5 period for the service business model without needing major repairs or part replacements. The replacement cost could be significant. A detailed risk analysis needs to be conducted to control the cost associated with risks.

Thirdly, if LiDAR sensors and UAS become lower cost and easier to use, the market could be flooded with competition just like what happened with standard drone photo and video imagery. The founders will have to be vigilant with keeping track of market trends to exit or pivot before the market crashes.

Moving Forward

As co-founder, I (Tyler Groth) have decided to move forward with this venture in the Fall of 2017. The co-founder and salesperson are still interested at this point, but this summer we are all too busy with our current jobs in order to move forward. I have already been working on a contingency in case the co-founder loses interest. I have connected with a small company in San Diego with a business model very similar to the Product model analyzed in this paper. The San Diego company's founder wants to expand into the Pacific North West and could be a great partner for start-up capital and in industry knowledge. Another group I have spoken with is a small Manned LiDAR company. They have expressed interest in partnering with an Unmanned LiDAR group. This company is local and already has connections with utility companies in the area. When I return from work travel at the end of the summer I plan to sit down with my co-founder and gauge his level of interest in working with either or both the San Diego company and the local NW company. Business talks are very preliminary at this point but we both feel it'd be beneficial to partner with an established group to mitigate our sales risk.

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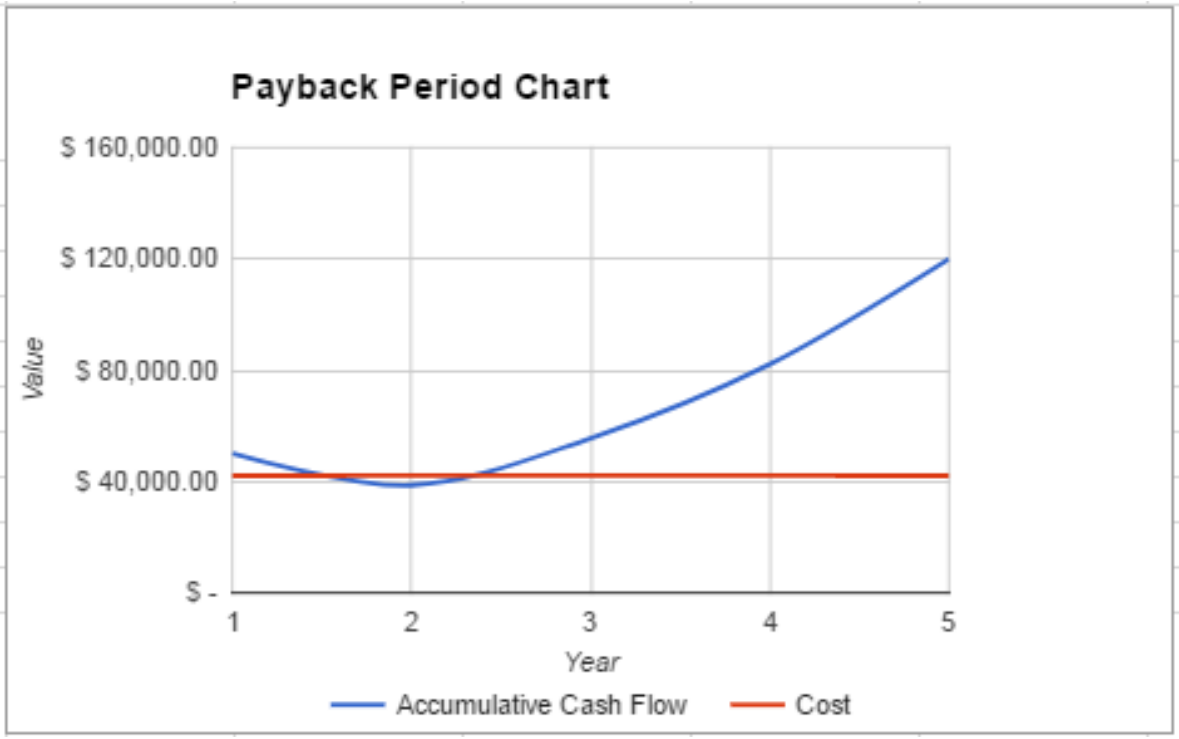
Appendix

A - 5-Year Cash Flow of Service Model

Service Model		Cost										Benefit					
		Fixed Cost				Variable Costs						s Revenue - 15% annual incre					
Year	LiDAR/Drone System Cost	Office workspace	Insurance	Software Licensing Fee	Work Truck	Drone Operator /Data Processor	Schedule Manager	Sales Rep	Marketing	Travel Cost	Total Cost	# of acres of Photo	# of acres of LiDAR	# of acres of Photo and LiDAR	Total Revenue	Cash Flow	Benefit/ Cost Ratio
0	$(42,200.00)										$ (42,200.00)				$ -	$(42,200.00)	
1	$ -	$ (1,200.00)	$ (3,000.00)		$ (6,000.00)	$ -	$ -	$ (7,800.00)	$ (9,800.00)	$ (1,600.00)	$ (27,800.00)	20.00	60.00	80.00	$ 78,000.00	$ 50,200.00	2.81
2	$ -	$(22,500.00)	$ (3,000.00)	$ (1,700.00)	$(20,000.00)	$ (11,040.00)	$(25,000.00)	$ (8,970.00)	$ (8,970.00)	$ (1,840.00)	$ (101,180.00)	23.00	69.00	92.00	$ 89,700.00	$(11,480.00)	0.89
3	$ -	$(22,500.00)	$ (3,000.00)	$ (1,700.00)	$ -	$ (12,696.00)	$(25,750.00)	$ (10,315.50)	$ (10,315.50)	$ (2,116.00)	$ (86,277.00)	26.45	79.35	105.80	$ 103,155.00	$ 16,878.00	1.20
4	$ -	$(22,500.00)	$ (3,000.00)	$ (1,700.00)	$ -	$ (14,600.40)	$(26,522.50)	$ (11,862.83)	$ (11,862.83)	$ (2,433.40)	$ (92,048.55)	30.42	91.25	121.67	$ 118,628.25	$ 26,579.70	1.29
5	$ -	$(22,500.00)	$ (3,000.00)	$ (1,700.00)	$ -	$ (16,790.46)	$(27,318.18)	$ (13,642.25)	$ (13,642.25)	$ (2,798.41)	$ (98,593.13)	34.98	104.94	139.92	$ 136,422.49	$ 37,829.36	1.38
															NPV =	$53,120.43	1.51
															IRR =	53%	

B - Payback Period Chart of Service Model



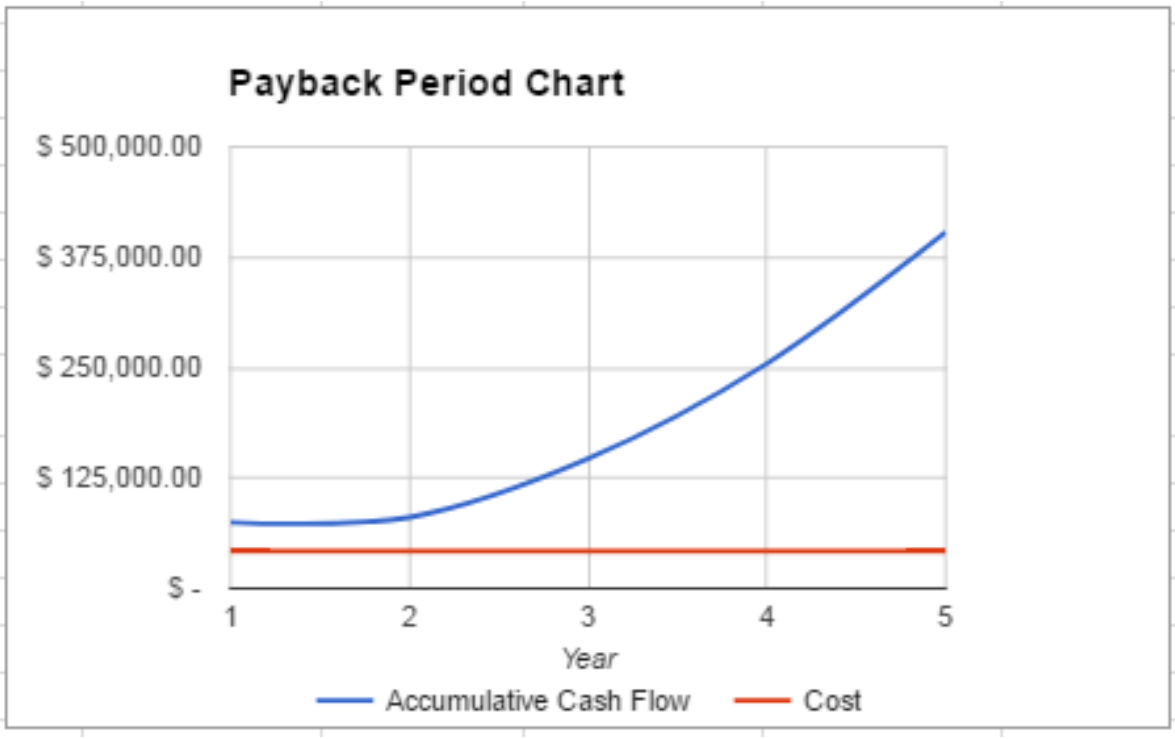
C - Sensitivity Analysis of Service Model

Year	50% chance of 15% annual sales increase	25% chance of 25% annual sales increase	25% chance of 10% annual sales increase	Expected Value
0	-$42,200	-$42,200	-$42,200	-$42,200
1	$50,200	$50,200	$50,200	$50,200
2	-$11,480	-$6,200	-$14,120	-$10,820
3	$16,878	$29,550	$10,938	$18,561
4	$26,580	$49,403	$16,554	$29,779
5	$37,829	$74,388	$22,786	$43,208
NPV =	$53,120	$109,363	$28,535	$61,034.71
IRR =	52.58%	74.54%	38.08%	56%

D - 5-year Cash Flow of Product Model

Product model		Cost									Benefit				
		Fixed Cost				Variable Cost					Sales Revenue				
Year	# of drones	LiDAR/Drone Demo Unit	Office workspace	Insurance	Work Truck	Assembly Engineer	Sales Rep	Marketing	LiDAR/Drone part Cost	Total Cost	LiDAR/Drone System	Training Class	Total Revenue	Cash Flow	Benefit/Cost Ratio
0		$ (42,200.00)								$ (42,200.00)			0	$ (42,200.00)	
1	4	$0	$ (1,200.00)	$ (3,000.00)	$ (6,000.00)	$ -	$ (30,000.00)	$ (32,000.00)	$ (168,800.00	$ (241,000.00)	$300,000	$16,000	$316,000	$ 75,000.00	1.24
2	6	$0	$ (22,500.00	$ (3,000.00)	$ (20,000.00)	$ (80,000.00)	$ (45,000.00)	$ (45,000.00)	$ (253,200.00	$ (468,700.00)	$450,000	$24,000	$474,000	$ 5,300.00	0.96
3	8	$0	$ (22,500.00	$ (3,000.00)		$ (82,400.00)	$ (60,000.00)	$ (60,000.00)	$ (337,600.00	$ (565,500.00)	$600,000	$32,000	$632,000	$ 66,500.00	1.06
4	10	$0	$ (22,500.00	$ (3,000.00)		$ (84,872.00)	$ (75,000.00)	$ (75,000.00)	$ (422,000.00	$ (682,372.00)	$750,000	$40,000	$790,000	$ 107,628.00	1.10
5	12	$0	$ (22,500.00	$ (3,000.00)		$ (87,418.16)	$ (90,000.00)	$ (90,000.00)	$ (506,400.00	$ (799,318.16)	$900,000	$48,000	$948,000	$ 148,681.84	1.13
													NPV =	$ 264,878.34	1.098
													IRR =	140%	

E - Payback Period Chart of Product Model



F - Sensitivity Analysis of Product Model

Year	50% chance of 2 unit annual increase	25% chance of 1 unit annual increase	25% chance of 3 unit annual increase	Expected Value
0	-$42,200	-$42,200	-$42,200	-$42,200
1	$75,000	$75,000	$75,000	$75,000
2	$5,300	-$16,500	$27,100	$5,300
3	$66,500	$22,900	$110,100	$66,500
4	$107,628	$42,228	$88,156	$86,410
5	$148,682	$61,482	$148,464	$126,827
NPV =	$264,878.34	$104,159.46	$303,718.43	$234,408.64
IRR =	140%	95%	160%	136%